Characterizing Small K2 Planets with the HARPS-N Spectrograph

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Follow-up studies of the small planets detected by Kepler have revealed a remarkable diversity of planet densities, indicating that predicting planetary properties from a radius measurement alone could lead to significant errors in our estimate of the frequency of rocky (and possibly habitable) worlds. We propose to study the relationship between the masses, radii, insolation, and metallicities of small planets by targeting moderately bright stars with K2 and conducting follow-up high-precision radial velocity (RV) measurements with HARPS-N. Our goal is to obtain a mass precision of 15%, the minimum value required to distinguish between compositional models.

This project requires new K2 data for two reasons. First, most transiting small planets detected by Kepler orbit stars too faint for RV observations, and some of the bright Kepler host stars are not amenable to RV observations because of the variability of the host star or the presence of nearby stars. Second, the anticipated number of small planets orbiting quiet, bright stars detected in K2 campaigns to date (Fields 0-5) is small.

We propose a list of 3729 FGKM dwarf stars that are bright enough for RV follow-up and faint enough that they will not require unreasonably large K2 target apertures. We searched for all $V < 12$ stars that will be on silicon during Campaigns 6, which is accessible to HARPS-N. We then used the available photometry to remove likely giants and constrain the properties of the remaining dwarfs.

We will identify promising planet candidates in K2 photometry using the planet detection pipeline developed by team members Vanderburg and Johnson. We will vet candidates by measuring the centroid shifts, acquiring high-resolution adaptive optics images, and gathering high-resolution spectra. We will then conduct HARPS-N observations of the best candidates with small radii, and spanning the range of insolation and stellar metallicities.

The HARPS-N instrument, located at the Telescopio Nazionale Galileo in La Palma, Spain, is an extremely stable, fiber-fed echelle spectrograph designed to measure radial velocities with exquisite precision. All of the members of our proposal team are members of the HARPS-N Consortium, which has 80 nights per year of guaranteed time per year. The follow-up of small planets from Kepler and K2 is the top scientific priority of HARPS-N. PI D. Charbonneau is chair of the HARPS-N Science Team and the Target Selection Team.

We will deliver the following value added community resource products to the NASA archives: light curves and estimated stellar parameters for all targets; phase-folded light curves, reconnaissance imaging, and reconnaissance spectra for planet-candidate host stars; and tables of precise radial velocities for the subset of planet candidate host stars pursued by HARPS-N.

Our campaign to measure the masses of small K2 planets with precision better than 15% will have a tremendous impact on our understanding of small planets. By increasing the number of small planets with precise mass and radius estimates, we will enable investigations of the fraction of rocky planets as a function of planetary and stellar parameters such as orbital period, the presence of additional planets, and stellar metallicity. Improving our understanding of the relationship between the masses and radii of small planets will provide useful background information when selecting targets for atmospheric characterization with the James Webb Space Telescope and prioritizing the follow-up observations of planets detected by the Transiting Exoplanet Survey Satellite.